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Bandwidth Management Using BDPBR Approach

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***Abstract:** Bandwidth Management attempts to manage the bandwidth assigned to virtual paths. The main objective of Bandwidth management is effective utilization of bandwidth. This paper presents about bandwidth management in ATM networks and its importance in the overall performance of ATM networks. In this paper a new approach is proposed to manage bandwidth in ATM networks. This new approach is called Bandwidth Demand Prediction and Bandwidth Recycling (BDPBR) for dynamically managing the bandwidth. BDPBR approach involves Understanding the traffic behavior, Estimation of Bandwidth demand of the traffic flowing through the VP's and Recycle the unused bandwidth without changing the existing bandwidth reservation.*

***Keywords:** Virtual paths, Bandwidth management, BDPBR, ATM, Bandwidth Demand*

I. INTRODUCTION

One of the important issues in ATM networks is bandwidth management and allocation. Bandwidth management attempts to manage the capacities assigned to the different VPs that flow through a physical link. Sometimes, parts of the network become under-utilized and other parts congested as shown in fig 1. When this occurs, some connections are rejected that could be accepted if the traffic load were better balanced. The network rejects a connection when there is not enough free capacity in the VP it is going to traverse, because the existing connections are employing almost the whole bandwidth reserved for this VP.

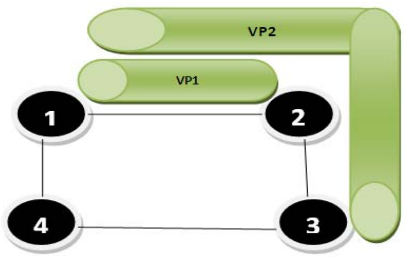


Fig.1: Network with Congested and Underutilized Bandwidth

Josee-Luis Marvzo et al. [JPR2K] discussed about bandwidth management by managing the capacities assigned to VP's. When some VPs become congested, then some connections that could be accepted if the traffic load were better balanced may be rejected. Two actions are usually taken by the bandwidth management system as illustrated in the below figure.

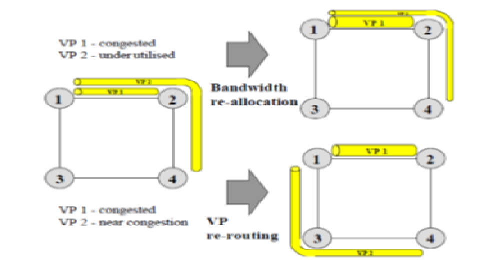


Fig.2: Bandwidth Management Using re-allocation and re-routing

II. Drawbacks of Existing Approaches

1. Repeated fitness function evaluation for complex problems are often the most prohibitive and limiting segment of artificial evolutionary algorithms. Finding the optimal solution to complex high-dimensional, multimodal problems often requires very expensive fitness function evaluations.

2. Genetic algorithms do not scale well with complexity. That is, where the number of elements which are exposed to mutation is large there is often an exponential increase in search space size.

3. Operating on dynamic data sets is difficult, as genomes begin to converge early on towards solutions which may no longer be valid for later data. Several methods have been proposed to remedy this by increasing genetic diversity somehow and preventing early convergence, either by increasing the probability of mutation when the solution quality drops (called *triggered hypermutation*), or by occasionally introducing entirely new, randomly generated elements into the gene pool (called *random immigrants*).

III. Proposed Bandwidth Management Technique

In this paper a new approach is proposed to manage bandwidth in ATM networks. This new approach is called Bandwidth Demand Prediction and Bandwidth Recycling (BDPBR) for dynamically managing the bandwidth. BDPBR approach involves, (i) Understanding the traffic behavior, (ii) Estimation of Bandwidth demand of the traffic flowing through the VP's, and (iii) Recycle the unused bandwidth without changing the existing bandwidth reservation.

The BDPBR approach involves two-step process as illustrated in fig 3.2. Many ATM networks will have some bandwidth reservation requirements, where a particular amount of bandwidth is requested when creating connections. The reserved bandwidth may not be used 100%, so some part of the bandwidth remains unused and it can be recycled.

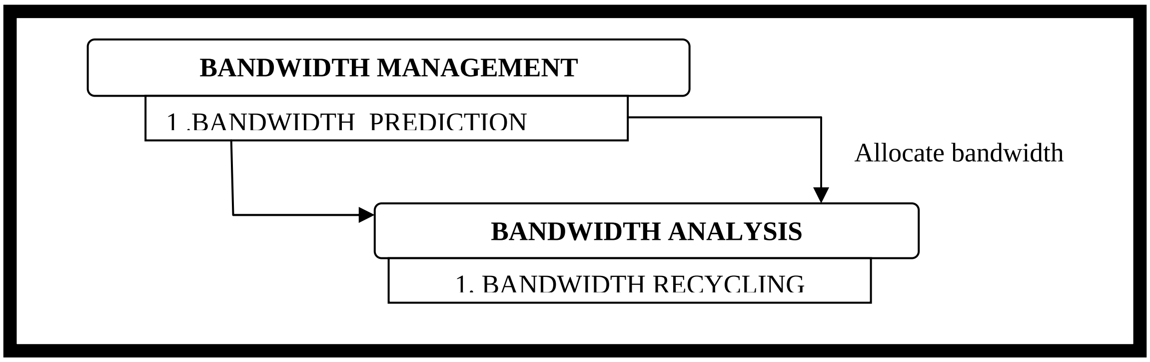


Fig.3: Steps in Bandwidth Management

In this paper a novel Bandwidth Prediction algorithm is proposed, it involves four phases namely (1) Input phase, (2) clustering phase, (3) comparison phase, and (4) update phase. After prediction, bandwidth is allocated in a generous manner as the unused bandwidth can be recycled in the second step of BDPBR approach. In recycling step, the unused bandwidth is identified and it is recycled.

3.1. Bandwidth Prediction

Intelligent controllers, which predict bandwidth-demand patterns to enable better VP management, have the potential to revolutionize ATM networks. In fact transmission efficiency can be improved by dynamically changing bandwidths of VP's based on demand.

The VP bandwidth is dynamically altered in accordance to the traffic demand. For efficient management of VP bandwidth, an accurate estimate of bandwidth-demand of the traffic flowing through the VPs is required. In order to make an accurate estimate of the bandwidth demand, a proper understanding of the behaviour of the traffic is required. The behaviour of the traffic is usually expressed in terms of its past statistical properties.

3.1.1. .Bandwidth Prediction using NBP technique

In this paper a novel Bandwidth Prediction algorithm is proposed, it involves the following four phases

1. Input Phase
2. Clustering Phase
3. Comparison Phase
4. Update Phase

Algorithm: Novel Bandwidth Prediction

1. Identify the link or virtual path for which bandwidth is to be predicted.
2. Calculate the Peak Bandwidth Utilized (PBU), Least Bandwidth Utilized (LBU) and Average Bandwidth Utilized (ABU) for the first hour slot (i.e. may be 12 hour or 6 hour or 4 hour slot).

PBU = **MAX** $(B_1, B_2, \ldots\ldots\ldots B_n)$

LBU = **MIN** $(B_1, B_2, \ldots\ldots\ldots B_n)$

LBU = **MIN** $(B_1, B_2, \ldots\ldots\ldots B_n)$

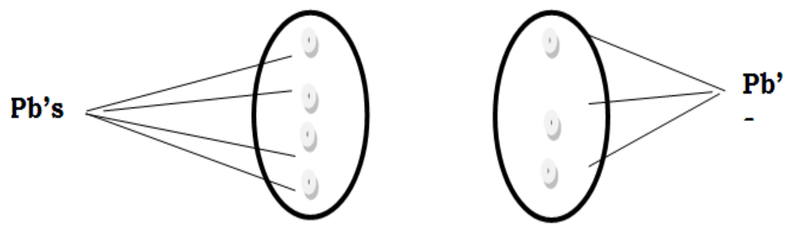
$$ABU = \frac{\sum_{i=1}^{n} B_i}{n}$$

Where n is the number of bandwidth slcts

3. Calculate Pb_1 (bandwidth Prediction for slot 1) for the selected Virtual path.
4. Calculate the PBU, LBU and ABU for the next hour slot (i.e. may be 12 hour or 6 hour or 4 hour slot).

$$Pb_1 = \frac{PBU + LBU + ABU}{3}$$

5. Calculate the PBU, LBU and ABU for the next hour slot (i.e. may be 12 hour or 6 hour or 4 hour slot).
6. Calculate Pb_2 for the selected Virtual path.
7. Group bandwidth predictions Pb_1, Pb_2, Pb_3, …… into different clusters based on a threshold value (fig 3.4).



Cluster-1 *Cluster-2*

Fig.4: Cluster formation of bandwidths based on threshold value

8. Select the cluster which contains the maximum no of Pb's (bandwidth predictions).
9. The calculated PB is the final bandwidth predicted.

$$PR = \frac{\sum_{i=1}^{n} Pb_i}{n}$$

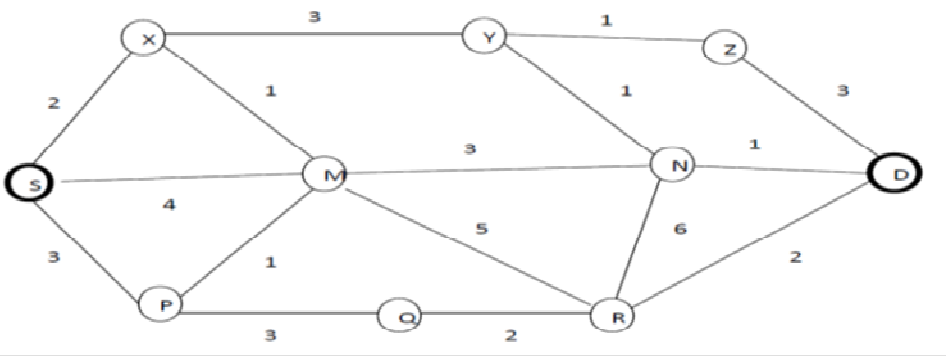


Fig.5 Simple Nwtwork with simple 10 nodes

1) ***Input Phase :*** In this phase for a particular link the input values will be generated for bandwidth prediction. Daniel Won-Kyutting et al. [DCD+02] presented a new model called Service Provisional Model (SPM) and resource model of a bandwidth allocation time table (BATT).

Table 1: Virtual Path table for the network in fig3.5

Path	Nodes
VP0	S-X-Y
VP1	S-M-N
VP2	S-P-Q
VP3	Y-Z-D
VP4	Y-N-D
VP5	M-N-D
VP6	M-R-D
VP7	Q-R-D
VP8	Z-D
VP9	R-D

2) ***Clustering Phase :*** The different input values generated in phase-1 are not taken directly as input. First they are grouped into clusters and then given as inputs. The clustering is based on similarity in the values. That is two input values are grouped into one cluster if the difference between them is less than a threshold value.

3) ***Comparison Phase :***In this phase the clustered input values are compared and a solution is found considering the traffic history of ATM network. From the generated clusters a single cluster is selected which contains maximum number of Pbs. If any two clusters contain same number of Pbs then a cluster that contains maximum Pb value is selected.

4) ***Updating Phase :*** In this phase the newly generated solution is stored in corresponding tables for future use. The selected PB is stored in corresponding tables for future use i.e. these values can also be used to predict the bandwidth in the next cycle. After prediction the bandwidth allocation is done and any unused bandwidth is recycled in the next phase of BDPBR approach.

3.2. Bandwidth allocation

In bandwidth allocation phase bandwidth allocation is done based on the bandwidth predictions. The bandwidth allocation (AB) for VP0 can be done by using the below formula

$$AB^{(VP0)} = \frac{\frac{\sum_{i=1}^{n} PBU_i^{(VP0)}}{n} + \frac{\sum_{i=1}^{n} LBU_i^{(VP0)}}{n} + \frac{\sum_{i=1}^{n} ABU_i^{(VP0)}}{n} + PB^{(VP0)}}{n-1} +$$

Where n is the number of slots

3.3. Bandwidth Recycling

Bandwidth recycling represents recycling the unused bandwidth without changing the existing bandwidth reservation. Many ATM networks will have some bandwidth reservation requirements, where a particular amount of bandwidth is requested when creating connections. The reserved bandwidth may not be used 100%, so some part of the bandwidth remains unused and it can be recycled. To achieve this, proposed scheme uses Bandwidth recycling mechanism. It allows other subscriber station to utilize the unused bandwidth when it is available.

3.3.1 Bandwidth Recycling using proposed system

David Chuck et al. [DaMo10] classified the applications based on the traffic into two types. They are Constant Bit Rate (CBR) applications and Variable Bit Rate (VBR) applications. In CBR data transmission is in constant rate. So SS rarely adjusted the reserved bandwidth. It is hard to have unused bandwidth in this type of applications. However in VBR it is very high rate in the data generated rate. So in VBR reserved bandwidth may not be fully utilized all the time. The analysis focuses on investigating the percentage of unused bandwidth of VBR traffics. They classified the traffic loads into four stages namely stage-1 (Light load), stage-2 (Moderate load), stage-3 (Heavy load) and stage-4 (Full load). In this paper, the number of stages is reduced to three as listed below.

Stage-1: Light Load (LL)

The total used bandwidth is much less than the granted bandwidth. This can be illustrated as **UBW << GBW**

Satge-2: Balanced Load (BL)

The total used bandwidth is equal to the available bandwidth. This can be illustrated as **UBW == GBW**

Stage-3: Heavy Load (HL)

The total bandwidth demand is high than the available/granted bandwidth. This case is very rare in BDPBR approach as it predicts the bandwidth in advance and always allocates bandwidth little higher than the prediction, so that the unused bandwidth can be recycled in the next phase. The bandwidth recycling can be done only in the stage-1. Because this is the only case where there is unused bandwidth. The next phase concentrates on the calculating the unused bandwidth.

Algorithm: Bandwidth Recycling

1. Start
2. Analyze the bandwidth utilized.
3. Identify the stage

4. if stage belongs to 1

   Calculate the unused bandwidth for frame 'i" by using the below formula

   UNBW (i) = GBW(i) – UBW(i)

   Recycle the "n" units of UNBW

   End if

5. If stage belongs to 2

   No recycling. As there is no unused bandwidth

For example consider the below table 3.4 illustrating the bandwidth statistics of VPs in a network. The table represents the allocated bandwidth, used bandwidth, unused bandwidth and recycled bandwidth.

IV. Advantages of Proposed BDPBR Approach

1. The Novel Bandwidth prediction suits well for high-dimensional complex problems, the Input phase and clustering phase spits the input samples into groups thereby reducing the complex problems sets into simplified clustered groups.
2. The Novel bandwidth prediction does not require any extra expenses for dealing with complex problems.
3. The recycling of unused bandwidth is a major advantage in the BDPBR approach, as it reduces unutilized bandwidth.
4. The BDPBR approach is also a mechanism for controlling congestion in ATM networks.
5. BDPBR approach increases the overall performance of the network.

V. Results

The Proposed bandwidth prediction technique performance is illustrated in the below fig 3.8. The simulation results showed that the algorithm predicts bandwidth accurately in most cases and in some cases it allocates a little more than the actual bandwidth, this extra bandwidth is recycled. For example consider the below table 3.2 illustrating the bandwidth predictions of a link in a network. The table represents the actual demand and predicted bandwidth in Mbps.

Table 2: Bandwidth Prediction Using BDPBR approach

Path	Predicted Bandwidth (in Mbps)	Actual Bandwidth Demand (in Mbps)
VP0	0.86	1.12
VP1	0.94	1.1
VP2	1.08	1.12
VP3	1.09	1.0
VP4	1.3	1.4
VP5	1.7	1.0
VP6	1.15	1.1
VP7	1.19	1.0
VP8	1.3	1.0
VP9	0.75	1

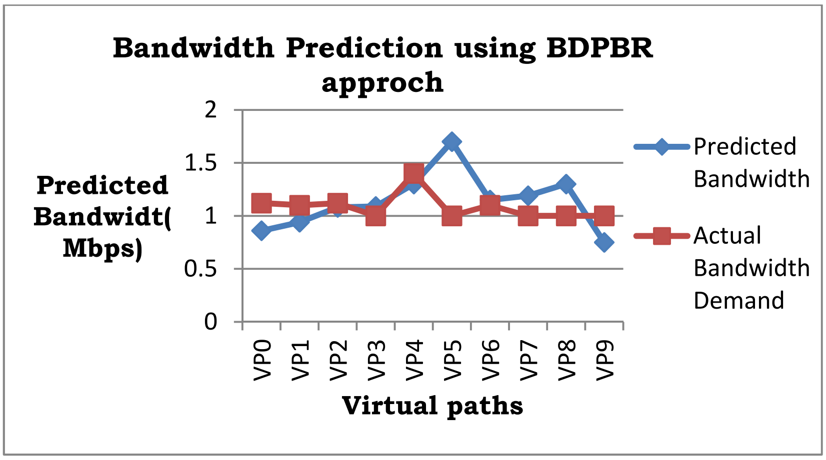


Fig.6: Performance analysis of Bandwidth Prediction using BDPBR approach

After the bandwidth prediction is completed the allocation is done using BDPBR approach and its performance is illustrated by the below fig 3.9. For example consider the below table 3.3 illustrating the bandwidth allocations of VPs in a network. The table represents the actual demand and allocated bandwidth in Mbps. From the table it's evident that the allocation is always closer to the demand. The extra bandwidth if any will be recycled in the next phase.

Table 3: Bandwidth Allocation using BDPBR approach

Path	Bandwidth units in Mbps	
	Actual Demand	Allocated Bandwidth (through BDPBR approach)
VP0	1.12	1.15
VP1	1.1	1.25
VP2	1.12	1.31
VP3	1.0	1.5
VP4	1.4	1.44
VP5	1.0	1.4
VP6	1.1	1.51
VP7	1.0	1.45
VP8	1.0	1.7
VP9	1	1.1

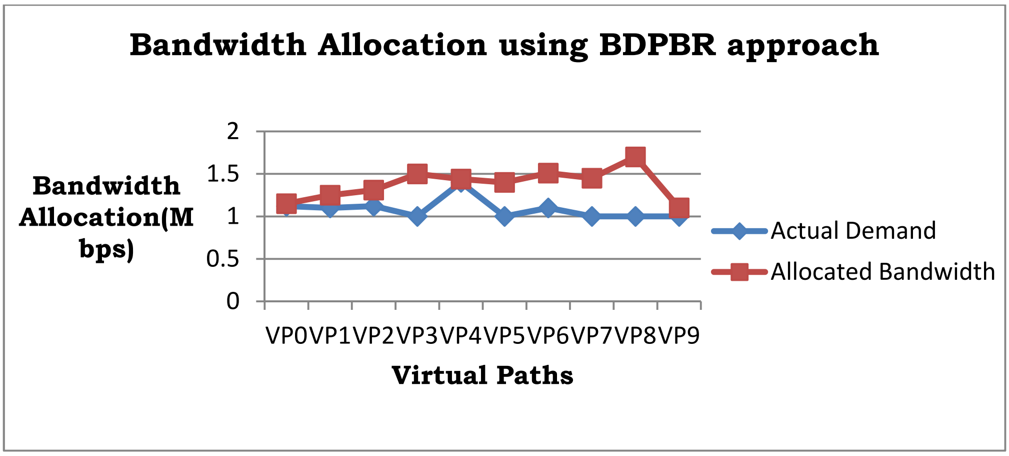


Fig.7: Performance analysis of Bandwidth allocation using BDPBR approach

The unused bandwidth is recycled by BDPBR approach, in fig 3.10 the simulation results show that 30% of the unused bandwidth can be recycled without having an effect on the overall performance of the network.

Table 4: Bandwidth recycling using BDPBR approach

Link Paths	Bandwidth units in Mbps			
	Allocated Bandwidth	Used Bandwidth	Unused Bandwidth	Bandwidth recycled
VP0	1.15	1.15	0	0
VP1	1.25	1.05	0.2	0.06
VP2	1.31	1.31	0	0
VP3	1.5	1.5	0	0
VP4	1.44	0.94	0.5	0.15
VP5	1.4	1.2	0.2	0.06
VP6	1.51	1.51	0	0
VP7	1.45	1.15	0.3	0.09
VP8	1.7	1.7	0	0
VP9	1.1	1.1	0	0

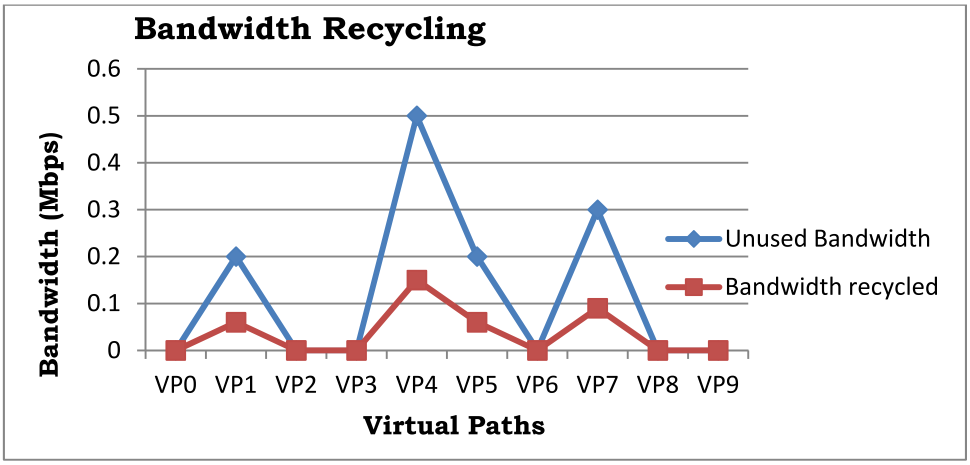


Fig.8: Performance analysis of Bandwidth recycling using BDPBR approach

VI. CONCLUSION

This Paper described the existing bandwidth management techniques and gave detail description of the proposed bandwidth management technique for dynamically managing the bandwidth in ATM networks. This paper first described the existing bandwidth prediction techniques and bandwidth recycling technique used in IEEE 802.16 networks. Later it described the proposed approach for bandwidth prediction and recycling. The paper ends with the results and summary of the proposed bandwidth management technique.The simulation results showed that the proposed bandwidth management technique is able to recycle at least 30% of the unused bandwidth. This recycling helps to improve the performance of ATM network.

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